



Solar Technologies for BoP Communities

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May 2011

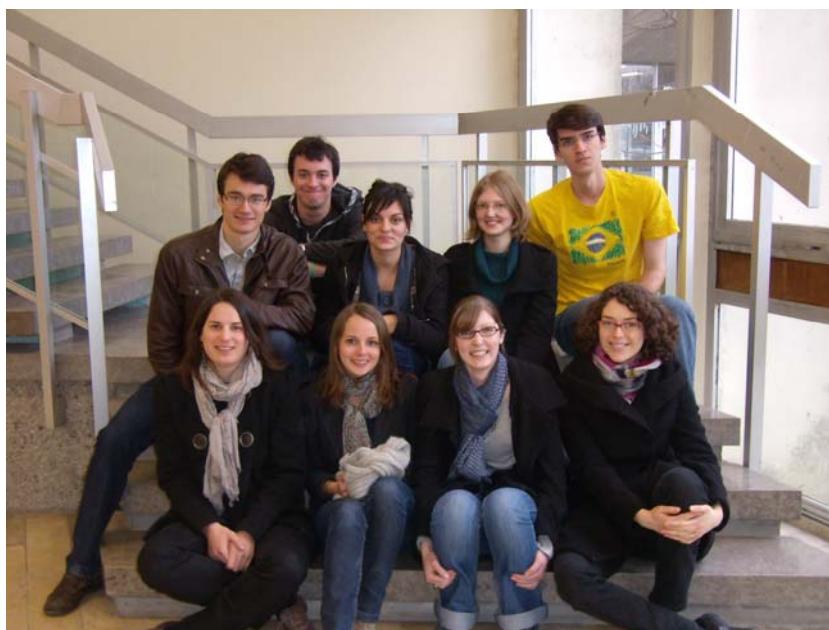
Acknowledgement: We thank Professor Anand Rao of IIT Mumbai for his feedback on this project and its validation and Tamas Medovarski for editorial corrections of this report.

Abstract by Shyama V. Ramani

One of the important objectives of Friend in Need is to explore how rural villages in developing countries can have access to energy to satisfy their needs – while minimizing the carbon imprint. In Kameshwaram, most houses have electric connections, but for collective needs there is still not enough. For example, the fishermen of Kameshwaram would like to have a lamp to guide them home from sea. Often when they try to return home from sea under the cover of darkness, the only visible lights are those of the port of Nagapattinam. Therefore, they requested information on a lamp, which they would be able to see from a distance of about 10 kms. In turn I requested the MSc. students of the Grenoble (France) engineering school ENSE to identify the types of existing solar energy based products that could be bought by low-income communities, develop a set of indicators to evaluate them and finally suggest a solution for the problem of the fishermen of Kameshwaram. This is their report. I thank them most sincerely for a very good report.

Presentation

We are a group of nine students from the engineering school ENSE³ (Ecole Nationale Supérieure de l'Énergie, l'Eau et l'Environnement), a part of the Grenoble INP group. We are in the ASI (Automatique, Systèmes et Information) program which develops skills in analysis, modelling and simulation of dynamic systems, design and optimisation of automatic control systems, design of embedded control systems, system supervision, monitoring and reconfiguration, signal acquisition processing, personal development, management and industrial engineering. The main disciplines cover different fields: automatic control, signal/information processing, mecatronics, production management, condition monitoring, diagnosis, maintainability.



From left to right,

Top row: Philippe Signoret West, Vincent Diaz, Camille Jourdain, Cécile Grimbert, Roberto Medeiros de Souza.

Bottom row: Laura Michel, Elise Goujaud, Claire Madec, Maëlle Kabir-Querrec

Our project, led and inspired by Dr. Shyama V. Ramani, consists of studying different solar based technologies useful in rural India, based social, economic, environmental and technical criteria. We are focusing on three types of technologies: solar signal lights, solar cookers and solar powered water purifiers. We will develop a set of criteria for each technology that can be used to choose adequate and reliable products.

A pilot program, using products chosen based on these criteria, will be run in Kameshwaram, a village in the southeastern state of Tamil Nadu, India. Kameshwaram, located in the Nagapattinam district, has about 5,000 inhabitants (1,450 households). The relationship with the village was cultivated by Friend-in-Need, an NGO created to help the population devastated by the tsunami in 2004.

Assessment grid

We have defined an assessment grid which contains technical, economic, environmental and social criteria to evaluate products adapted to a given population.

| | All | Cookers | Lamps | Purifiers |
|--------|--------------------------------|-------------------------------------|------------------------------------|--------------------------------------|
| Social | Possibility of theft | Food capacity | Possibility of collective purchase | Comprehension by users of advantages |
| | Skill required for maintenance | Place of use (exterior or interior) | | |
| | Individual vs. collective use | | | |

| | | | | |
|---------------|--|--|--------------------------------------|------------------------------------|
| Health | Hazards risked by using the technology | Existence of prohibited materials | | Compliance with sanitary standards |
| | | Existence of burn hazard | | Comparison to current water |
| | | | | Percentage of bacteria eliminated |
| | | | | Diseases eliminated/treated |
| | | | | Origin of water treated |
| Environmental | Possibility of recycling the product | | Type of lamp (LED, CFL, sodium) | |
| | Possibility of recycling the battery | | | |
| | Possibility of integration in the environment | | | |
| Economic | Price (compared with the average household income) | | | |
| | Cost including maintenance, cleaning, turnover | | | |
| | Proximity of suppliers | | | |
| | Availability of product in the Indian market | | | |
| Technical | Ease of use | Ease of installation | Power of light | Accessibility of technology |
| | Life cycle | Tools and containers needed to operate | Battery voltage | Amount of water purified |
| | Robustness | Maximum temperature | Autonomy of system | Power of purifying element |
| | Maintenance frequency | Orientation frequency | Distance of visibility of light | Capacity/throughput |
| | Investment by population | Time needed to reach desired temperature | Intensity of light | Size |
| | Installation, maintenance and cleaning hazards | Possibility to control temperature | Automatic or manual switch | Weight |
| | Maintenance skill required | Power | Pole height | Dependence on external power |
| | Installation skill required | Stability in wind or adverse weather | Stability in wind or adverse weather | |

Product evaluation

Solar lighting

The solar powered lights discussed are being evaluated mainly for visibility at large distances. It has proven difficult to find information regarding the distance from which a light is visible from suppliers.¹



The first product is a LED-based solar street light supplied by OmegaSolar. This lamp has a large luminosity (1500 to 2400 lumens²), is relatively easy to install, and requires little maintenance. This model has three modules so it lights up in three directions. It has three day autonomy, allowing it to work through periods of low light, such as monsoon. There is also a protection against corrosion which will be important if the product is installed close to the beach. An important advantage is the use of LED instead of sodium lamp, which is better for the environment and

it has a longer life span. The main drawback is battery maintenance, as it requires quarterly maintenance by a technician or suitably trained layperson.



Another interesting product is the MV6 solar street light supplied by TATA BP SOLAR. This lamp has also a large luminosity (1800 lumens), provided by two 900 lumen modules. The lamp is a compact fluorescent light (CFL) and not a LED, but it is also relatively safe for the environment. CFLs have a shorter life cycle than LEDs but are comparably as efficient. The lamp has also an automatic dusk to dawn switch. The product has a good autonomy: it can work four days under bad weather. The battery has a five years life expectancy and the huge advantage is that it is recyclable.

The product is painted with a special paint to prevent erosion. It also needs a battery maintenance but only biannual.

¹ Flashing or blinking lights have not been analyzed, although they are being considered for the future.

² Lumen: a measure of the power of light, as perceived by a human eye.

Evaluation grid for solar lamps

| | Criterion | LED-Solar-Street-Light-OSL36312 (Omega Solar) | TATA BP SOLAR STREET LIGHT MV6 | Solar & Wind Hybrid Street Light (Sinostar) | Enolar Street Lighting System |
|-----------|--|--|--|--|---|
| Technical | Maintenance difficulty - (1 easy - 3 hard) | 3 | 3 | 3 | 3 |
| | Maintenance frequency -(1 rarely - 3 very often) | 1 | 1 | | 1 |
| | Ease of use - (1 easy - 3 hard) | 1 | 1 | 1 | 1 |
| | Lamp life expectancy | 50 000 hours | 6 000 to 15 000 hours | 50 000 hours (about 13 years if it is used 10 hours per day) | 6 000 to 15 000 hours |
| | Battery life expectancy | 3 to 4 years | 5years | 15 to 17 years without maintenance (GEL technology) | Tubular battery |
| | Robustness (1 weak - 3 strong) | 3 | 3 | 3 | 3 (it can withstand 90 MPH wind loads) |
| | Necessary skills | No | No | No | No |
| | Hazard (1 no danger - 3 dangerous) | 2 (handling of electrical components for the maintenance - acid battery) | 2 (handling of electrical components for the maintenance but there are many protections) | 2 (handling of electrical components for the maintenance) | 2 (handling of electrical components for the maintenance) |
| | Can be installed by general population? | No | No | No | No |

| | Criterion | LED-Solar-Street-Light-OSL36312 (Omega Solar) | TATA BP SOLAR STREET LIGHT MV6 | Solar & Wind Hybrid Street Light (Sinostar) | Enolar Street Lighting System |
|---------------|--|--|---------------------------------------|--|---|
| | Autonomy | At least 3 days (even during monsoon) | 4 days | At least 3 days | 3 days |
| | Automatic or manual switch | Automatic but possibility of manual switch | Automatic dusk to dawn operation | | Automatic Dusk to Dawn operation |
| | Visibility | | | | |
| | Mast height | 4,8 m | 4 m | 8 à 11 m | 5 m |
| | Corrosion protection | Yes (galvanised steel) | oui (special paint against corrosion) | | Yes (galvanised steel for battery enclosure and mast) |
| | Luminosity | 6 lux for 3,6m height | | 4,5 lux for 10m height | |
| | Intensity | 1500 to 2400 lumens (3 modules) | 1800 lumens (2 modules) | 2500 lumens | 900 lumen |
| | Battery voltage | 36 V | 12 V | 12 V | 12V |
| | Lamp power | 36 W | 11 W | 32 W | 11W |
| Economic | Availability in Indian market | Yes (Omega Solar Company) | Yes (TATA BP SOLAR) | No | Yes (Enolar Systems) |
| | Supplier location | Coimbatore (Tamil Nadu) | Bangalore | China | Bangalore |
| | Price | 33 000 rupees = 521,6 Euros | 58 330 rupees = 922 Euros | | |
| | Global cost | | | | |
| Environmental | Type of lamp | LED low consumption | CFL | LED | CFL |
| | Pollution generated in using the product | | | | |

| | Recyclable | No | Recyclable battery | Most of the product | |
|--------|---|--|---|--------------------------|-------------------------|
| Social | Collective or individual use | Collective | Collective | Collective | Collective |
| | Cleaning difficulty (1 easy - 3 hard) | 3 (solar panel cleaning - battery maintenance) | 3 (battery maintenance) | 3 (solar panel cleaning) | 3 (battery maintenance) |
| | Cleaning frequency | Quarterly | Biannual | Quarterly | Quarterly |
| | Does it correspond to the needs of the village? | Good luminosity and a good price. | More expensive but it could be more adapted and safe. | | |



Nearly at the end of our research project period, we found 'Aviation' solar lamps (commonly used at airports). We found the links to a production unit in China and we are sure that similar lamps are being made in India. <http://www.made-in-china.com/showroom/cnkestar/product-detail/yewERKMFSikL/China-Solar-Pharos-Light.html> They can be seen up to 10km and have the advantage of flashing with a frequency adjustable between 20 and 65 flashes per minute. Their purchase price is generally less than 300 €. They also have considerable autonomy in bad weather (about 15 days). However, the drawback of this product is that it does not come with a mast or a stand. The villagers therefore have to find or build a support system to

install it sufficiently high so as to be visible from a distance by the fishermen. In conclusion, though we were unable to find the product that met all the specifications required by the fishermen, the aviation lamp seems to be offering the second best option.

Solar cookers

Parabolic cookers

Parabolic cookers are cookers of relatively high power, so they allow for preparing food quickly. For example, a parabolic cooker with a diameter of 80cm can boil 1 liter of water in 30 minutes. One of the advantages of this kind of cooker is that they can be easily built, for example, by reusing an old TV parabolic antenna, which is simply covered with reflective material. The cost for building this kind of cooker is minimal and is limited just to the parabolic dish, and the price of the reflective material. In Europe, reflective paper costs approximately 25 Euros per square meter. For optimal cooking, it is necessary to rotate the cooker regularly (about every 30 minutes), so that it can reflect solar radiation on an optimal scale.



Solar box cooker

This is the solar cooker that is easiest to use. It allows to maintain a relatively high temperature inside a box for many hours. This kind of cooker, or oven, is good for preparing food that needs to be heated for many hours. Similarly to the technology of parabolic cookers, this kind of cooker can be easily built reusing old or readily available materials, allowing for low prices. Two important remarks are that this kind of cooker has to stay several hours under the sun before reaching its working



temperature and, like the parabolic cooker, must be rotated regularly to the optimal position.

Evaluation grid for solar cookers

| | Criterion | Parabolic cookers | Box cookers |
|-------------------|---|--|--|
| Technical | Maintenance (1 easy - 3 hard) | 1 | 1 |
| | Maintenance frequency (1 rarely - 3 very often) | Reflective surfaces must be maintained clean | Reflective surfaces must be maintained clean |
| | Ease of use (1 easy - 3 hard) | 2 | 1 |
| | Life expectancy | 10 to 20 years | 10 to 20 years |
| | Robustness (1 weak - 3 strong) | 2 | 2 |
| | Skill needed for use | No | No |
| | Use of special containers | Yes | Yes |
| | Time to reach the wanted temperature | 1h15 for 3l of water and an ambient temperature of 30°C with 1,40m parabol | 20 minutes with a cooker remained at sun all the morning (cooker at 90°C, ambient temperature at 30°C) |
| | Maximum temperature | About 200°C | About 100°C |
| | Power | 1000W/m ² | Depending on the diameter |
| | Period of reorientation | 1/4h to 1/2h | 1/4h to 1/2h |
| | Stability in wind (1 stable - 3 not stable) | 3 | 1 |
| | Hazard (1 No danger - 3 dangerous) | 2 | 1 |
| | Economic | Availability in Indian market | Yes |
| Supplier location | | | |
| Price | | | |
| Global cost | | | |
| Environmental | Pollution | None | None |
| | Recyclable | Depending on materials used for construction | Recyclable if it is an home-made cooker |
| Social | Collective or individual use | Depending on the size | Depending on the size |
| | Cleaning (1 easy - 3 hard) | 1 | 1 |
| | Cleaning frequency | Clean after use | Clean after use |
| | Capacity (1 small - 3 big) | 2 or 3 (30kg for 1,40m parabol) | 2 |
| | Interior or Exterior use | Exterior | Exterior |
| | Does it correspond to the population needs? | | |

Water purifiers

The third technology chosen for our project is water purifiers. The main standards to find the best product are price and sanitary performance. We must take into account the average income of Kameshwaram inhabitants, about 5000 rupees per month. Then we have the objective to find a system which destroys harmful bacteria and virus in humid area like India or in another part of the world where many diseases are carried by water.

To optimize our search, we have focussed on Indian market and some experiences by other NGOs all over the world. Finally, we find that two products stand out in the market. The first is Tata Swach, produced by Tata Company. The second is a Dutch system called Naiade which has been tested in many countries such as India and Pakistan, with the support of UNICEF and many other NGOs.

TATA Swach



Tata Swach is a system which does not need any additional water or electricity. This water purifier exists in two versions, costing between 749 and 999 rupees, available in the Indian market. Tata Swach is composed of a series of three filters which eliminate 80% of bacteria, viruses, protozoan and worm eggs present in polluted water.

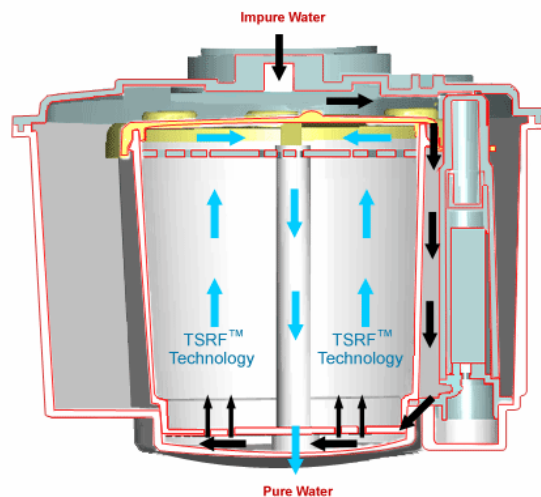
The filtering method is specific. Silver particles present in Tata Swach, stick to bacteria and then themselves fasten to rice husks. The sets which are made in this way, are big enough to be kept by sari material. Water is then cleaned out and drained away to a container.

Tata Swach is intended for a family of five and can treat 4 liters per hour. After filtering 3000 liters of water (about 6 months of use), users have to change filter cartridges. The cartridge change costs

299 rupees.

Tata Swach use is very simple and guarantees improvement of sanitary conditions.

The main argument to propose this system is price which is moderate enough low-income households.



NAIADE

Naiade system presents a different way from Tata Swach. First, suspended particles are removed with three filters. Then, an ultraviolet (UV) light is used to destroy remaining bacteria. The energy to power the UV light is generated with a standard photovoltaic (PV) panel and a rechargeable battery. Naiade helps in the improvement of sanitary conditions by destroying 95% of harmful pathogens

that cause diseases; including especially harmful and widespread ones such as typhus, cholera, dysentery and hepatitis.

It is intended to be used for large groups of people (4000 litres/day, good for approximately 400 people).

Technical assistance is necessary to change the battery (used to supply the light during adverse (low-light) weather conditions such as the monsoon period. Additionally, Naiade needs little check-upon service and maintenance. It suffices to clean the PV panel once a week.

Bringing Naiade to low-income communities is a campaign supported by UNICEF.

Evaluation grid for water purifiers

| | Criterion | Tata Swach | Naiade |
|---------------|---|--|--|
| Technical | Maintenance difficulty (1 easy - 3 hard) | 1 | 1 |
| | Maintenance frequency (1 rarely - 3 very often) | 1 | 2 |
| | Ease of use (1 easy - 3 hard) | 1 | 1 |
| | Life expectancy | Necessity to change the filters every 3 years | 10 years (UV lamp 10 000h of use) |
| | Robustness (1 weak - 3 strong) | 2 | 2 |
| | Necessary skills for product use | No | No |
| | Capacity | 9L contaminated water + 9L purified water | 100L |
| | Throughput | 3 to 4L/hour, 3000L per filter (200 days) | 300L/hour (4000L/day) |
| | Battery? | No | Yes |
| | Power of UV lamp | N/A | 20W |
| | PV power | N/A | 80W (max) |
| | Size (L x l x h) | 30x28.2x57.2 cm | 54x75x140 cm |
| | Weight | 3kg | 44kg |
| | Need for water and electrical connection | No | No |
| Health | Origin of treated water | No need to use running water | No need to use running water |
| | Amount of bacteria eliminated | 0.8 | 0.95 |
| | Diseases treated | Bacteria, viruses, protozoan and worms eggs | Typhus, cholera, dysentery and hepatitis, amongst others |
| Economic | Availability in Indian market | Yes | No |
| | Location of suppliers | China | Netherlands |
| | Price | First version : IRP 749 Second version : IRP 999 cartridge : IRP 299 | EUR 3500 plus shipping to India |
| | Global cost | 1 cartridge every 6 months | |
| Environmental | Pollution | 0 | None, except battery if not recycled appropriately. |

| | | | |
|--------|--|--|---|
| | Recyclable | | Rechargeable battery may be recycled. |
| Social | Collective or individual use | Individual household (up to 5 people) | Collective (up to 400 people) |
| | Cleaning difficulty (1 easy - 3 hard) | 1 | 1 |
| | Cleaning frequency | Weekly cleaning for filters and containers | Cleaning for containers, solar panel and filters |
| | Capacity (1 small - 3 big) | 1 | 2 |
| | Interior or Exterior use | Both | Exterior |
| | Is it corresponding to the population needs? | Good price but not really as effective for treating diseases | Expensive but very effective for treated diseases |